OPERATOR'S MANUAL

for

DIRECT CAPACITANCE BRIDGE MODEL 75D (1 MHz)

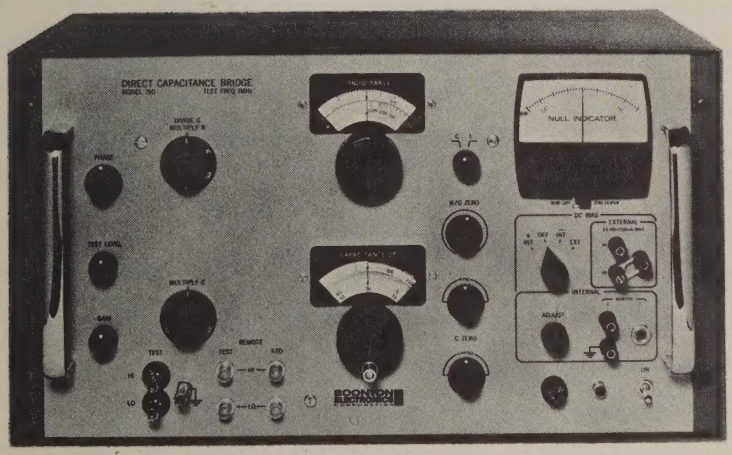

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TABLE OF CONTENTS

Paragraph:		Page:
	CHAPTER 1 - DESCRIPTION AND DATA	
1-1	Introduction	1-1
1-2	Purpose and Use	1-1
1-3	Technical Characteristics	1-2
	CHAPTER 2 - OPERATION	
2-1	General	2-1
	Section I. PRELIMINARY OPERATING INSTRUCTIONS	
2-2	Controls and Indicators	2-1
2-3	Starting Procedure	2-7
2-4	Preliminary Adjustments	2-8
2-5	Zero Balancing the Bridge	2-9
	Section II. AMPLITUDE-MODE MEASUREMENTS	
2-6	General	2-10
2-7	C, G, and R_p Measurements	2-10
2-8	L, G, and R_p Measurements	2-11
	Section III. PHASE-MODE MEASUREMENTS	
2-9	General	2-15
2-10	C Measurement Only	2-16
2-11	L Measurement Only	2-17
	Section IV. SINGLE-LIMIT TESTING	
2-12	General	2-19
2-13	Single-Limit Capacitance Test	2-19
2-14	Single-Limit Inductance Test	2-22
	Table of Replaceable Parts	P.L.1

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CHAPTER 1

DESCRIPTION AND DATA

1-1 INTRODUCTION

This instruction manual describes Direct Capacitance Bridge Model 75D (1 MHz) and contains complete operating procedures and data as well as a table of replaceable parts and a schematic diagram.

The Capacitance Bridge comprises a modified Young bridge, null detector, crystal-controlled oscillator, power supply, and bias supply and can be operating without any external equipment. All operating controls and indicators are mounted on the front panel, and the ac power cable is bracket mounted on the rear of the unit. If required, the 75D may be removed from its cabinet and installed in a standard 19-inch rack.

1-2 PURPOSE AND USE

The 75D can be used as a conventional laboratory bridge for precise measurements of capacitors, inductors, and semiconductor devices, or it can be used as a go/no-go test equipment for single-limit sorting applications. The 75D provides direct readings for parallel capacitance (C), conductance (G), and equivalent parallel resistance (R_p) values, while parallel inductance (L) values are readily determined by simple computation. The 75D is insensitive to capacitance from either side of a specimen to ground; therefore it provides accurate readings even in the presence of relatively large stray capacitance. Thus, the direct (3-terminal) capacitance of either 2-terminal or 3-terminal specimens may be measured, and a test jig can be used during single-limit testing without introducing errors due to cable or jig capacitance. Test specimens may be biased directly by the internal dc supply, or an external bias source can be applied through front-panel terminals. External standards also can be connected at the front panel to perform comparison or differential measurements.

1-3 TECHNICAL CHARACTERISTICS

a. Capacitance Measurements.

Capacitance Range.....0 to 1000 pF

Capacitance Resolution and Accuracy:

MULTIPLY C Setting	Capacitance Range (pF)	Resolution		Accuracy	
		Phase Mode (pF)	Amplitude Mode (pF)	Phase Mode	Amplitude Mode
1.0	0 to 1000	0.2	0.2	$\pm (0.25 + \frac{10}{Q})\% + 0.5pF$ *	$\pm 0.25\% + (1000/R_p + 0.5)pF$
0.1	0 to 100	0.02	0.02	$\pm (0.25 + \frac{3}{Q})\% + 0.05pF$	$\pm 0.25\% + (1000/R_p + 0.05)pF$
0.01	0 to 10	0.002	0.002	$\pm (0.25 + \frac{3}{Q})\% + 0.005pF$	$\pm 0.25\% + (1000/R_p + 0.005)pF$
0.001	0 to 1	0.0002	0.0005	$\pm (0.25 + \frac{3}{Q})\% + 0.001pF$	$\pm 0.25\% + (1000/R_p + 0.001)pF$
0.0001	0 to 0.1	0.00005	0.0005	$\pm (2 + \frac{10}{Q})\% + 0.00005pF$	$\pm 2\% + (1000/R_p + 0.00005)pF$

Where R_p is the equivalent parallel resistance of the specimen in ohms.

* Q must be 10 or greater

b. Inductance Measurement

Inductance Range.....25 μH to 25 mH

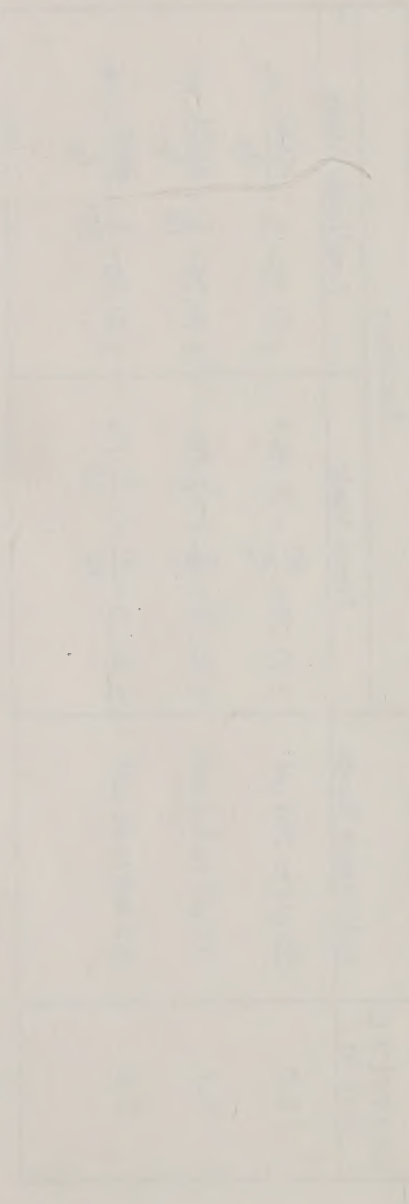
Inductance Accuracy:

MULTIPLY C Setting	Inductance Range	Accuracy	
		Phase Mode	Amplitude Mode
1.0	25 μH to 250 μH	$\pm (0.25 + \frac{10}{Q} + 2L)\%$ *	$\pm (0.25 + 2L + \frac{4000L}{R_p})\%$
0.1	250 μH to 2.5 mH	$\pm (0.25 + \frac{3}{Q} + \frac{L}{5})\%$	$\pm (0.25 + \frac{L}{10} + \frac{4000L}{R_p})\%$
0.01	2.5 mH to 25 mH	$\pm (0.25 + \frac{3}{Q} + \frac{L}{50})\%$	$\pm (0.25 + \frac{L}{50} + \frac{4000L}{R_p})\%$

Where L is the inductance of the specimen in millihenries

R_p is the equivalent parallel resistance of the specimen in ohms

* Q must be 10 or greater



c. Conductance Measurement

Conductance Range (amplitude mode only) .....0 to 1000 μmhos

Conductance Resolution and Accuracy:

DIVIDE G Setting	Conductance Range	Resolution	Accuracy
1	0 to 1000 μmhos	5 μmho	$\pm(10+\frac{Q}{500})\%$ + 10 μmhos
10	0 to 100 μmhos	0.5 μmho	$\pm(5+\frac{Q}{500})\%$ + 1 μmho
100	0 to 10 μmhos	0.05 μmho	$\pm(5+\frac{Q}{500})\%$ + 0.1 μmho
1000	0 to 1 μmho	0.01 μmho	$\pm(5+\frac{Q}{500})\%$ + 0.01 μmho

d. Resistance Measurement

Resistance Range (amplitude mode only).....1 KΩ to 100 MΩ

Resistance Resolution and Accuracy:

MULTIPLY R Setting	Resistance Range (ohms)	Resolution	Accuracy
1	1 K to 100 K	$(R_p/10^3)\%$	$\pm(10 + Q/500 + R_p/10^3)\%$
10	10 K to 1 M	$(R_p/10^4)\%$	$\pm(5 + Q/500 + R_p/10^4)\%$
100	100 K to 10 M	$(R_p/10^5)\%$	$\pm(5 + Q/500 + R_p/10^5)\%$
1000	1 M to 100 M	$(R_p/10^6)\%$	$\pm(5 + Q/500 + R_p/10^6)\%$

Where R_p is the equivalent parallel resistance of the specimen in ohms.

e. Test Signal

Frequency	1 MHz (±200 Hz) crystal controlled
Level	Continuously adjustable from 250 mV to 1 Mv; to 15 mV for phase mode

f. DC Bias

Internal	Continuously adjustable from -6V to +150V
External, 2 Term	Up to ±400V at 100 mA from HI post to LO post
External, 3 Term	Up to ±400V at 100 mA from HI post to ground or from LO to ground (total potential from HI and LO posts to ground not to exceed 400V at 100 mA)

g. Power Requirements ..... 105 - 125V, 50/60 Hz or 210 - 250V, 50/60 Hz

h. Power Consumption ..... 50 W

i. Physical Characteristics

Dimensions:

Installed in cabinet	11-1/4" h x 19-1/2" w x 12-3/4" d
Cabinet removed (for rack mounting)	10-1/2" h x 19" w x 10-1/8" d

Weight:

Installed in cabinet	35 lbs.
Without cabinet	25 lbs.

CHAPTER 2

OPERATION

2-1 GENERAL

Before performing any of the measurements or tests given in this chapter, observe the preliminary operating instructions in Section 1 and thoroughly review the function of each control and indicator listed in Table 2-1. During operation, refer to the applicable equation in Paragraph 1-3 for accuracy information, especially when measuring or testing low-Q specimens.

Section 1. PRELIMINARY OPERATING INSTRUCTIONS

2-2 CONTROLS AND INDICATORS

All operating controls and indicators on the 75D are functionally described in Table 2-1. Reference designations are provided in the second column of the table to facilitate the identification of each item when referring to the schematic diagram. Complete familiarity with the control and indicator functions is recommended before operation of the 75D is attempted.

Table 2-1. Controls and Indicators

Item	Ref. Desig.	Description and function
CAPACITANCE control	C311	Bridge balancing variable capacitor used to measure capacitance. Provides pF readings on a two-section dial. Upper dial section is calibrated in increments of 100 with the left half of each increment coded black and the right half coded red. The lower section vernier dial consists of two concentric scales calibrated in increments of 5 which contain unit graduations with 1/5 subdivisions. Black numbers on the vernier dial complement the readings obtained on the black-coded region of the upper dial. Red numbers on the vernier dial complement the readings obtained on the red-coded region of the upper dial.
MULTIPLY C switch	S301	Rotary switch with five capacitive decade positions. Used with the CAPACITANCE control (above) whose reading is multiplied by the MULTIPLY C factor. Serves to expand the CAPACITANCE dial and to facilitate fractional pF measurements.
C ZERO COARSE and FINE controls	C302 C301	Correlated variable capacitors. Used to set up the 75D for operation by balancing the capacitive portion of the bridge network (with CAPACITANCE dial set at zero).

Table 2-1. Controls and Indictors (contd)

Item	Ref. Desig.	Description and function
CONDUCTANCE control	R308	Continuously variable resistor. Initially set at zero when bridge is being balanced. Dual-scale dial provides direct readings of test specimen's parallel conductance and equivalent parallel resistance. Conductance (G) scale calibrated in μmhos, and resistance (R) scale calibrated in ohms.
DIVIDE G/MULTIPLY R switch	S302	Rotary switch with 4 resistive decade positions. Extends the range of the CONDUCTANCE control by using the switch factor to divide the CONDUCTANCE G-scale reading and to multiply the R-scale reading.
R/G ZERO control	R310	Variable resistor. Used to balance the resistive portion of the bridge network (with the CONDUCTANCE dial set at zero).
TEST LEVEL control	R305	Variable resistor. Provides continuous control of test-signal level from 1 mV (fully counterclockwise) to 250 mV (fully clockwise).
GAIN control	R139	Variable resistor. Used to control gain for both the phase detector and the amplitude detector. Fully clockwise position provides maximum gain.

Table 2-1. Controls and Indicators (contd)

Item	Ref. Desig.	Description and function
PHASE control	C108	Continuously variable capacitor. Provides the proper phase relationship between reference and test signals so that the phase detector is insensitive to test specimen losses.
C/L switch	S303	Two-position rotary switch. Normally, the C position is used for capacitance measurements and tests, and the L position is used for inductance measurements and tests. However, the normal switch positions are reversed temporarily during phase adjustments (Par. 3-10, 3-11, 3-13, and 3-14) whenever the MULTIPLY C switch is in the 1 position.
NULL INDICATOR	M101	Meter indicator. Continuously monitors the output of the bridge circuit. The meter circuit is either amplitude sensitive or phase sensitive in accordance with the position of the meter switch (below).
Meter switch	S101	Two-position slide switch used in conjunction with the NULL INDICATOR. ZERO LEFT position: Connects the NULL INDICATOR to the amplitude detector, and the meter is sensitive to both C and G. Meter zero is the extreme left marking on the LO sector of the meter scale.

Table 2-1. Controls and Indicators (contd)

Item	Ref. Desig.	Description and function
Meter switch (contd)	S101	ZERO CENTER position: Connects the NULL INDICATOR to the phase detector, and the meter is sensitive to C while ignoring G. Meter sensitivity is increased by a factor of 10 (20 dB). Meter zero is the midscale marking; therefore, a zero-balance indication for the ZERO CENTER position should be at midscale. If the bridge circuit is unbalanced, the meter indicates whether the imbalance is caused by LO or a HI capacitance.
DC BIAS:		
Switch	S201	Four-position rotary switch used to select the following bias voltages: +INT: Internal bias up to +150 volts. OFF: Disables internal bias supply. -INT: Internal bias up to -6 volts. EXT: Disables internal bias supply and connects the bridge to the EXTERNAL binding posts.
EXTERNAL HI, LO, and ⏚ binding posts	----	Used to connect external bias (up to 400 V at 100 mA, maximum). A jumper is installed between the LO and ground terminals for 2-terminal bias applications. The jumper is removed for 3-terminal bias applications to permit independent biasing at the HI and LO posts. The EXTERNAL HI, LO, and ground binding posts are dc

Table 2-1. Controls and Indicators (contd)

Item	Ref. Desig.	Description and function
EXTERNAL HI, LO, and ⏚ binding posts (contd)	----	extensions of the corresponding TEST and REMOTE TEST terminals on the front panel.
INTERNAL ADJUST control	R201	Variable resistor. The 10-revolution control knob adjusts internal bias levels from -6V to +150V when the DC BIAS switch is in the +INT or -INT position.
INTERNAL MONITOR E and ⏚ binding posts	----	Terminals used to connect a dc voltmeter for metering internal bias voltage.
INTERNAL MONITOR I jack	J201	Normal-through jack with make-before-break contacts; used to connect a dc milliammeter for metering internal bias current.
Power switch	S401	Toggle switch. Controls ac power applied to the 75D.
Pilot lamp	PL401	Lamp indicator. Glows when ac power is applied to the 75D.
Fuse	F401	Protects equipment against overloads.
TEST binding posts	----	Test terminals used to connect capacitive specimens. TEST HI and LO binding posts used for two-terminal specimens, and TEST HI, LO, ⏚ used for three-

Table 2-1. Controls and Indicators (contd)

Item	Ref. Desig.	Description and function
TEST binding posts (contd)	----	terminal specimens. The TEST HI and LO binding posts are terminals in the test arm of the bridge, and the ⏚ binding post is at chassis ground.
REMOTE TEST coaxial connectors	J303 J304	BNC test terminals used to connect capacitive specimens. The REMOTE TEST HI and LO inner conductors are in parallel with the corresponding TEST HI and LO binding posts (above), and the BNC outer conductors are at chassis ground.
REMOTE STD coaxial connectors	J301 J302	BNC test terminals used to connect inductive specimens as well as external standards or balancing capacitors. The REMOTE STD HI and LO inner conductors are terminals in the standard arm of the bridge, and the BNC outer conductors are at chassis ground.
Ac power connector	P401	Three-terminal plug termination on power cable. Connects 75D to an ac power source.

2-3 STARTING PROCEDURE

Set the power switch to ON. If the 75D is to be operated in the amplitude mode, allow 15 minutes for warm-up. For phase-mode operation, allow one hour warm-up to ensure thermal stabilization of the phase detector circuit.

2-4 PRELIMINARY ADJUSTMENTS

Perform the preliminary adjustments on the front panel of the 75D in accordance with Table 2-2.

Table 2-2. Preliminary Adjustments.

Item	Setting or position
CAPACITANCE main dial and vernier dial	0
CONDUCTANCE G-scale dial	0
MULTIPLY C switch	1
DIVIDE G/MULTIPLY R switch	1000
R/G ZERO control	12 o'clock
C ZERO FINE and COARSE controls	12 o'clock
C/L switch	C
TEST LEVEL control	Fully clockwise
GAIN control	Fully clockwise
PHASE control	12 o'clock
Meter switch	ZERO LEFT
DC BIAS switch	OFF
DC BIAS INTERNAL ADJUST control	Fully counterclockwise
Terminal shield	Installed on TEST binding posts

2-5 ZERO BALANCING THE BRIDGE

a. General. The zero-balance procedure (b, below) is a basic procedure that is performed during each measurement and test procedure in this chapter. Therefore, familiarization with zero balancing is recommended before proceeding with the measurements or tests. During operation, any of the following conditions will require zero balancing the bridge:

1. The setting of the MULTIPLY C switch is changed.
2. The setting of the DIVIDE G/MULTIPLY R switch is changed.
3. The setting of the C/L switch is changed.
4. The position of the GAIN control is changed.
5. The position of the TEST LEVEL control is changed.
6. Test leads, cables, or a test jig is connected to the 75D.
7. The terminal shield either is installed on the TEST binding posts or is removed.

b. Zero-Balance Procedure. Before performing the following procedure, check that no test specimen is connected to the 75D. A null indication is defined as minimum meter reading. For a complete null, the meter pointer must be within one subdivision of zero when the MULTIPLY C switch is at any position except 1. When the MULTIPLY C switch is at 1, the meter pointer must be within three subdivisions of zero for a complete null.

1. Adjust the C ZERO COARSE control for a null indication on the meter.
2. Adjust the C ZERO FINE control for a null indication.
3. Adjust the R/G ZERO control for a null indication.
4. Repeat the above steps until a complete null is obtained.

NOTE:

Whenever the DIVIDE G/MULTIPLY R switch is in the 1 position, adjust the CONDUCTANCE control for a null indication before performing Steps 1 thru 4, above.

Section 11. AMPLITUDE-MODE MEASUREMENTS

2-6 GENERAL

Use the amplitude mode of operation to measure the C, G, or R_p of capacitive specimens or the L, G, or R_p of inductive specimens. When reading values on the CAPACITANCE or CONDUCTANCE dials during the following procedures, apply the associated MULTIPLY C or DIVIDE G/MULTIPLY R factor to the reading.

2-7 C, G, AND R_p MEASUREMENTS

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If the test specimen is to be connected directly to the TEST binding posts, remove the terminal shield. If coaxial test leads or a test jig is to be used, connect the leads or jig to the REMOTE TEST coaxial connectors.

c. Determine the approximate capacitance value of the test specimen and set the MULTIPLY C switch as indicated in the chart below.

Approximate value of test specimen (pF)	MULTIPLY C switch setting
100 to 1000	1
10 to 100	.1
1 to 10	.01
0.1 to 1	.001
0 to 0.1	.0001

d. Zero balance the bridge in accordance with the procedure in Paragraph 2-5b.

e. Connect the test specimen either to the TEST binding posts (use the HI and LO posts for 2-terminal specimens and the HI, LO, and ⏚ posts for 3-terminal specimens) or to the test jig or test leads, as required.

f. Advance the CAPACITANCE control for a null indication on the meter.

g. Advance the CONDUCTANCE control for a null indication on the meter.

NOTE:

If the meter does not null, set the DIVIDE G/ MULTIPLY R switch to successively lower positions and adjust the CONDUCTANCE control until a null is reached. Then remove the specimen, set the CAPACITANCE and CONDUCTANCE controls at zero, and repeat Steps d thru g.

h. Repeat Steps f and g until complete null is reached.

i. Read the capacitance of the test specimen on the CAPACITANCE dial.

j. Read the conductance of the test specimen on the G scale of the CONDUCTANCE dial. If the MULTIPLY C switch is in the 1 position, correct the conductance reading in accordance with Figure 2-2. If the DIVIDE G/MULTIPLY R switch is in the 1 position, correct the conductance reading in accordance with Figure 2-3.

k. Read the equivalent parallel resistance of the test specimen on the R scale of the CONDUCTANCE dial. However, if a conductance correction was made in Step j, relate the R-scale reading to the corrected G value.

2-8 L, G, AND R_p MEASUREMENTS

In this procedure, the inductance of the test specimen is measured in terms of equivalent capacitance, which then is translated to an inductance value by simple computation.

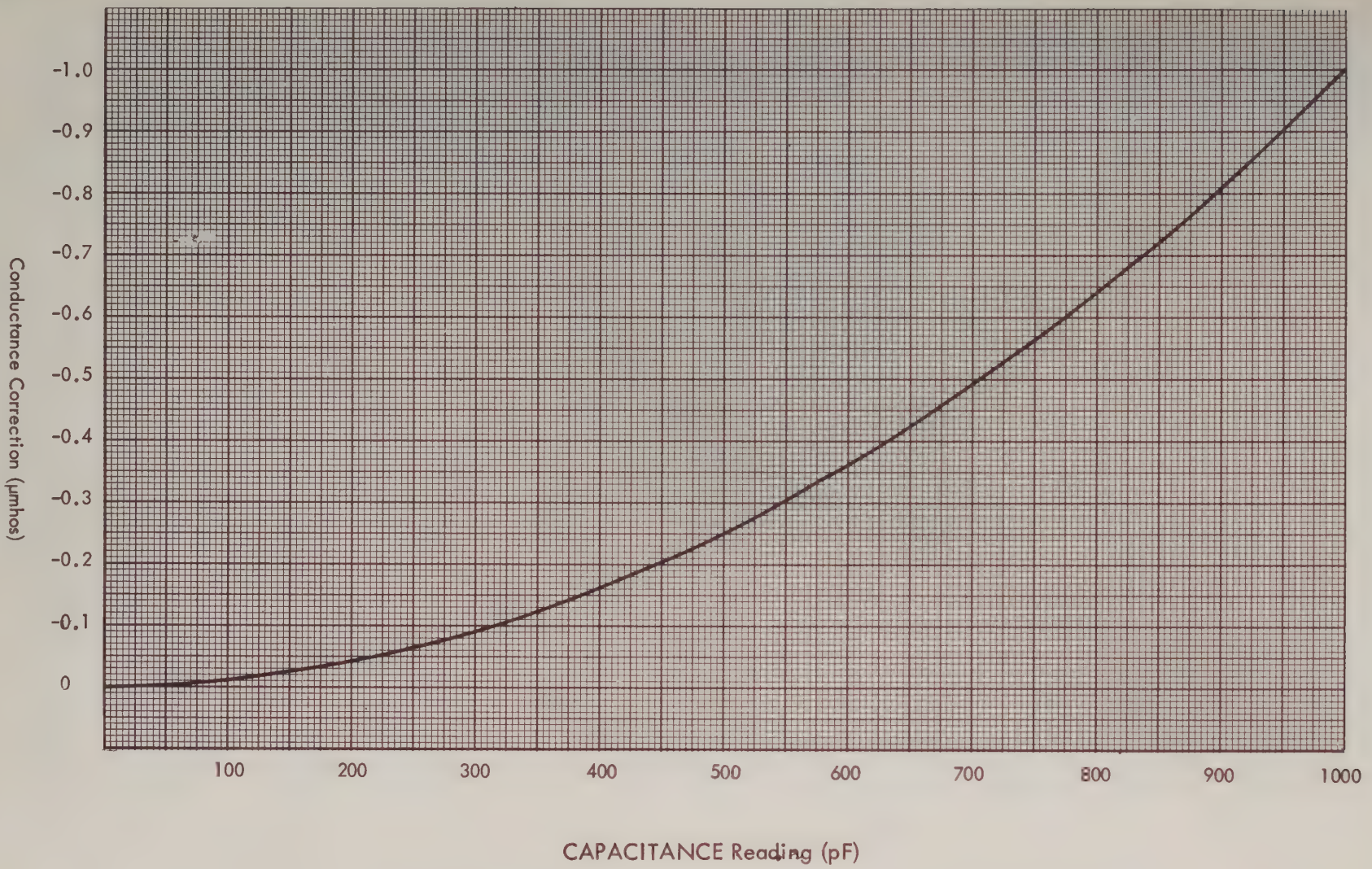


Figure 2-2. Conductance Correction for MULTIPLY C X1 Range.

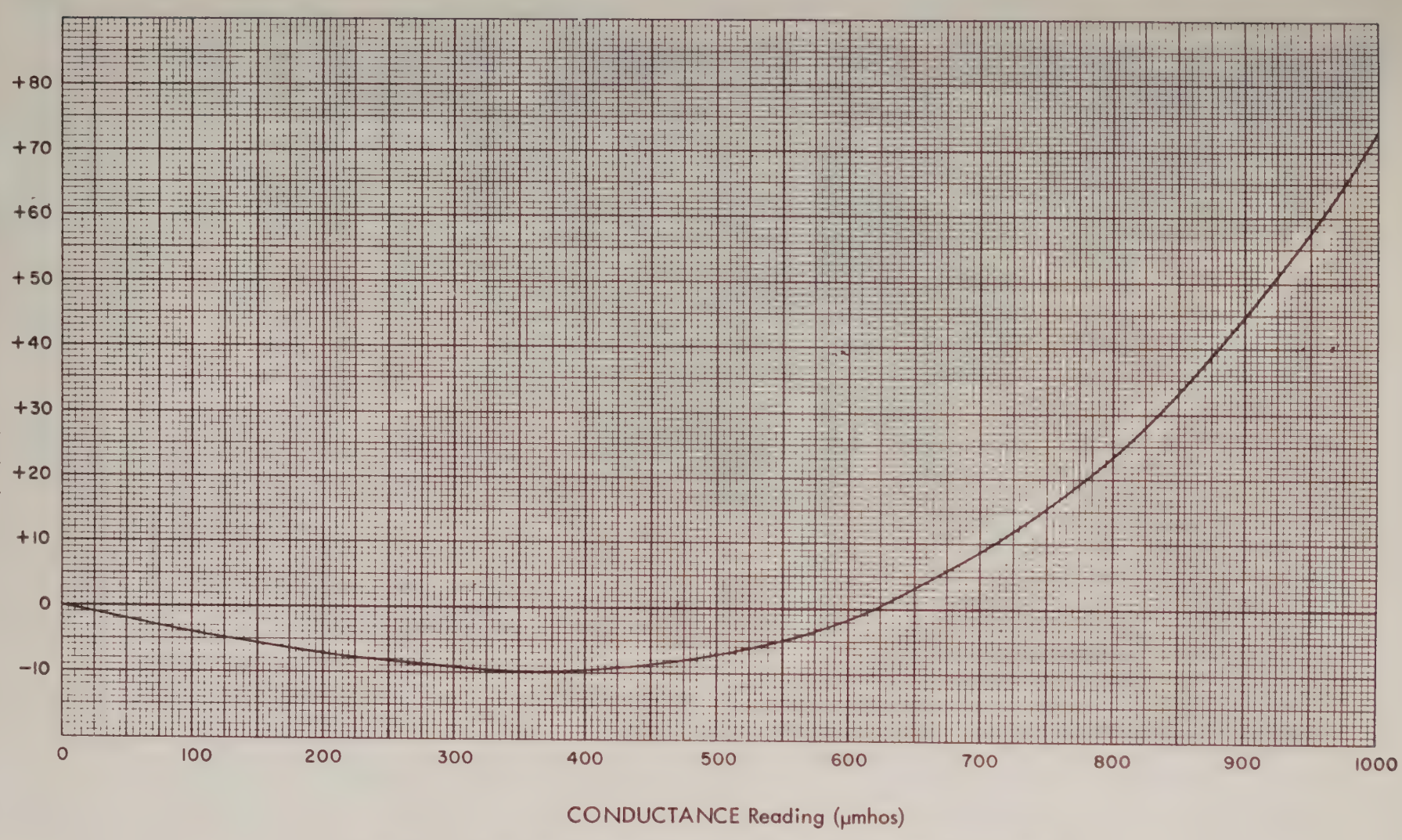


Figure 2-3. Conductance Correction for DIVIDE G/MULTIPLY R X1 Range.

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If coaxial test leads or a test jig is to be used, connect the item to the REMOTE STD coaxial connectors.

c. Determine the approximate inductance of the test specimen and set the MULTIPLY C switch as indicated in the following chart.

Approximate value of test specimen	MULTIPLY C switch setting
25 μH to 250 μH	1
250 μH to 2.5 mH	.1
2.5 mH to 25 mH	.01

d. Set the C/L switch to the L position.

e. Zero balance the bridge (Par. 2-5b).

f. Connect the test specimen to the REMOTE STD coaxial connectors (or to the test jig or test leads, if used).

g. Advance the CAPACITANCE control for a null indication on the meter.

h. Advance the CONDUCTANCE control for a null indication on the meter.

NOTE:

If the meter does not null, set the DIVIDE G/ MULTIPLY R switch to successively lower positions and adjust the CONDUCTANCE control until a null is reached. Then remove the specimen, set the CAPACITANCE and CONDUCTANCE controls at zero, and repeat Steps e thru h.

i. Repeat Steps g and h until a complete null is reached.

j. Read the value on the CAPACITANCE dial and use the following equation to convert the capacitance reading to an inductance value:

$$L = \frac{25.33}{C}$$

Where

L = inductance in mH

C = CAPACITANCE dial reading in pF

k. Read the conductance of the test specimen on the G scale of the CONDUCTANCE dial. If the MULTIPLY C switch is in the 1 position, correct the conductance reading in accordance with Figure 2-2. If the DIVIDE G/MULTIPLY R switch is in the 1 position, correct the conductance in accordance with Figure 2-3.

l. Read the equivalent parallel resistance of the test specimen on the R scale of the CONDUCTANCE dial. However, if a conductance correction was made in Step k, relate the R-scale reading to the corrected G value.

Section 111. PHASE-MODE MEASUREMENTS

2-9 GENERAL

Use the phase mode of operation to measure C or L when the R_p or G measurement is not required. The following two procedures respectively measure capacitance and inductance by phasing out the resistive component introduced by the test specimen so that the meter is insensitive to R_p (and its reciprocal, G). When reading values on the CAPACITANCE dial during the following procedures, apply the MULTIPLY C factor to the reading.

2-10 C MEASUREMENT ONLY

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If the test specimen is to be connected directly to the TEST binding posts, remove the terminal shield. If a test jig or coaxial test leads are to be used, connect the jig or leads to the REMOTE TEST coaxial connectors.

c. Determine the approximate capacitance value of the test specimen and set the MULTIPLY C, DIVIDE G/MULTIPLY R, and C/L switches to the positions indicated in the chart below. (Do not adjust the CONDUCTANCE control.)

Approximate value of test specimen (pF)	MULTIPLY C switch	DIVIDE G/ MULTIPLY R switch	C/L switch	CONDUCTANCE control G scale
100 to 1000	1	1	L	+1000
10 to 100	.1	1	C	-100*
1 to 10	.01	10	C	-100*
0.1 to 1	.001	100	C	-100*
0 to 0.1	.0001	1000	C	-100*

* Tenth (red) subdivision on G scale to the left of zero.

d. Zero balance the bridge (Par. 2-5b).

e. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

f. Refer to the chart in Step c, above, and set the CONDUCTANCE control to the required position.

g. Adjust the PHASE control until the meter needle is at midscale.

h. Return the CONDUCTANCE control to zero on the G scale.

i. If the C/L switch is at C, proceed to Step l. If the C/L switch is at L, set it to the C position.

j. Set the meter switch to ZERO LEFT and zero balance the bridge (Par. 2-5b).

k. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

l. Connect the test specimen either to the TEST binding posts (use the HI and LO posts for 2-terminal specimens and the HI, LO, ⏚ posts for 3-terminal specimens) or to the test jig or test leads, as required.

m. Advance the CAPACITANCE control for an exact midscale indication on the meter.

n. Read the capacitance of the test specimen on the CAPACITANCE dial.

2-11 L MEASUREMENT ONLY

In this procedure, the inductance of the test specimen is measured in terms of equivalent capacitance, which then is translated to an inductance value by simple computation.

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If coaxial test leads or a test jig is to be used, connect the item to the REMOTE STD coaxial connectors.

c. Determine the approximate inductance value of the test specimen and set the MULTIPLY C, DIVIDE G/MULTIPLY R, and C/L switches to the positions indicated in the chart below. (Do not adjust the CONDUCTANCE control.)

Approximate value of test specimen	MULTIPLY C switch	DIVIDE G/ MULTIPLY R switch	C/L switch	CONDUCTANCE control G scale
25 μH to 250 μH	1	1	C	+1000
250 μH to 2.5 mH	.1	1	L	-100*
2.5 mH to 25 mH	.01	10	L	-100*

* Tenth (red) subdivision on G scale to the left of zero.

d. Zero balance the bridge (Par. 2-5b).

e. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

f. Refer to the chart in Step c, above, and set the CONDUCTANCE control to the required position.

g. Adjust the PHASE control until the meter needle is exactly at midscale.

h. Return the CONDUCTANCE control to zero on the G scale.

i. If the C/L switch is at L, proceed to Step l. If the C/L switch is at C, set it to the L position.

j. Set the meter switch to ZERO LEFT and zero balance the bridge (Par. 2-5b).

k. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

l. Connect the test specimen to the REMOTE STD coaxial connectors (or to the test jig or test leads, if used).

m. Advance the CAPACITANCE control for an exact midscale indication on the meter.

n. Read the value on the CAPACITANCE dial and convert the value to inductance using the following equation:

$$L = \frac{25.33}{C}$$

Where

L = inductance in mH

C = CAPACITANCE dial reading in pF.

Section IV. SINGLE-LIMIT TESTING

2-12 GENERAL

The single-limit testing mode of operation is an option that can be used for testing and sorting operations of capacitors, inductors, and semiconductor devices during production testing, incoming inspection, quality assurance, and similar applications. Normally, either a test jig or coaxial test leads are used to connect specimens to the 75D to facilitate testing. If feasible, however, test specimens may be connected directly to the front-panel terminals.

2-13 SINGLE-LIMIT CAPACITANCE TEST

The 75D is used in the following procedure to perform go/no-go tests of capacitive specimens that are to be sorted. In this test the 75D compares the capacitance of each specimen with either an upper-limit value or a lower-limit value that has been programmed into the Capacitance Bridge, and a go or no-go readout indicates the test result. Although the 75D can be programmed for only one limit, dual-limit tests may be performed by repeating the procedure for the other limit.

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If test specimens are to be connected directly to the 75D, remove the terminal shield from the TEST binding posts. If coaxial test leads or a test jig is to be used, connect the item to the REMOTE TEST coaxial connectors.

c. Determine the required limit value and set the MULTIPLY C, DIVIDE G/MULTIPLY R, and C/L switches to the positions indicated in the chart below. (Do not adjust the CONDUCTANCE control.) If the tolerance is in percentage, convert the percentage tolerance to capacitance values and algebraically add the required tolerance to the nominal value of the specimen. (For example, a ±5% tolerance for a nominal 100 pF capacitor converts to 5 pF and becomes 105 pF for the upper limit and 95 pF for the lower limit.)

Tolerance Limit (pF)	MULTIPLY C switch	DIVIDE G/ MULTIPLY R switch	C/L switch	CONDUCTANCE control G scale
100 to 1000	1	1	L	+1000
10 to 100	.1	1	C	-100*
1 to 10	.01	10	C	-100*
0.1 to 1	.001	100	C	-100*
0 to 0.1	.0001	1000	C	-100*

* Tenth (red) subdivision on G scale to the left of zero.

d. Zero balance the bridge (Par. 2-5b).

e. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

f. Refer to the chart in Step c, above, and adjust the CONDUCTANCE control to the required position.

g. Adjust the PHASE control until the meter needle is exactly at midscale.

h. Return the CONDUCTANCE control to zero on the G scale.

i. If the C/L switch is at C, proceed to Step l. If the C/L switch is at L, set it to the C position.

j. Set the meter switch to ZERO LEFT and zero balance the bridge (Par. 2-5b).

k. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

l. Advance the CAPACITANCE control to the required limit value. (For the 105 pF upper limit in the Step c example, the MULTIPLY C switch would be in the 1 position and the CAPACITANCE control would be advanced to 100 on the upper dial and to 5 on the lower dial. If the lower limit were required, the CAPACITANCE control would be advanced to 95 on the lower dial.)

m. The 75D now is programmed to perform single-limit, go/no-go tests. Sequentially connect the capacitive specimens to the test jig, coaxial test leads, or the TEST binding posts, as applicable, and observe and NULL INDICATOR meter.

1. Upper-Limit Test. For a go result, the meter must indicate in the LO sector of the meter scale. Midscale is the absolute upper limit. If the meter indicates in the HI sector of the scale, the specimen is higher in capacitance than the upper limit, and the test result is no-go.

2. Lower-Limit Test. For a go result, the meter must indicate in the HI sector of the meter scale. Midscale is the absolute lower limit. If the meter indicates in the LO sector of the scale, the specimen is lower in capacitance than the lower limit, and the test result is no-go.

2-14 SINGLE-LIMIT INDUCTANCE TEST

The 75D is used in the following procedure to perform go/no-go tests of inductive specimens that are to be sorted. In this test, the 75D compares the inductance (i.e., equivalent capacitance) of each specimen with either an upper-limit value or a lower-limit value that has been programmed into the Capacitance Bridge, and a go or no-go readout indicates the test result. Although the 75D can be programmed for only one limit, dual-limit tests may be performed by repeating the procedure for the other limit.

a. Check that the preliminary adjustments on the front panel are in accordance with Table 2-2.

b. If coaxial test leads or a test jig is to be used, connect the item to the REMOTE STD coaxial connectors.

c. Determine the tolerance limit required and set the MULTIPLY C, DIVIDE G/MULTIPLY R, and C/L switches to the positions indicated in the chart below. (Do not adjust the CONDUCTANCE control.) If the tolerance is in percentage, convert the percentage tolerance to inductance values and algebraically add the required tolerance to the nominal value of the specimen. (For example, a ±5% tolerance for a nominal 0.4 mH inductor converts to ±0.02 mH and becomes 0.42 mH for the upper limit and 0.38 mH for the lower limit.)

Tolerance Limit (pF)	MULTIPLY C switch	DIVIDE G/ MULTIPLY R switch	C/L switch	CONDUCTANCE control G scale
25 μH to 250 μH	1	1	C	+1000
250 μH to 2.5 μH	.1	1	L	-100*
2.5 mH to 25 mH	.01	10	L	-100*

* Tenth (red) subdivision on G scale to the left of zero.

d. Zero balance the bridge (Par. 2-5b).

e. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

f. Refer to the chart in Step c, above, and adjust the CONDUCTANCE control to the required position.

g. Adjust the PHASE control until the meter needle is exactly at midscale.

h. Return the CONDUCTANCE control to zero on the G scale.

i. If the C/L switch is at L, proceed to Step l. If the C/L switch is at C, set it to the L position.

j. Set the meter switch to ZERO LEFT and zero balance the bridge (Par. 2-5b).

k. Set the meter switch to ZERO CENTER. If necessary, adjust the C ZERO FINE control for a midscale meter indication.

l. Convert the inductance limit value to an equivalent capacitance value. Use the following equation:

$$C = \frac{25.33}{C}$$

Where

C = capacitance in pF

L = inductance in mH

(If the upper limit were required in the Step c example, 0.42 mH would convert to 60.31 pF. If the lower limit were required, 0.38 mH would convert to 66.66 pF.)

m. Advance the CAPACITANCE control to the capacitance value derived in Step l, above.

(For the 60.31 pF upper limit in the Step l example, the MULTIPLY C switch would be in the .1 position and the CAPACITANCE control would be advanced to 600 on the upper dial and to 3.1 on the lower dial. If the lower limit were required, the CAPACITANCE control would be advanced to 600 on the upper dial and to 66.6 on the lower dial.)

n. The 75D now is programmed to perform single-limit, go/no-go tests. Sequentially connect the inductive specimens to the test jig, coaxial test leads, or the REMOTE STD coaxial connectors, as applicable, and observe the NULL INDICATOR meter.

1. Upper-Limit Test. For a go result, the meter must indicate in the HI sector of the meter scale. Midscale is the absolute upper limit. If the meter indicates in the LO sector of the scale, the specimen is higher in inductance than the upper limit, and the test result is no-go.

2. Lower-Limit Test. For a go result, the meter must indicate in the LO sector of the meter scale. Midscale is the absolute lower limit. If the meter indicates in the HI sector of the scale, the specimen is lower in inductance than the lower limit, and the test result is no-go.

NOTE:

The HI and LO indications for the Step n tests, above, are the reverse of those obtained during the corresponding tests of capacitive specimens in Paragraph 2-13m.

TABLE OF REPLACEABLE PARTS
FOR MODEL 75D

NOTE: Components in the "Bridge" unit have not been included because, in general, their replacement must be followed by adjustments that require specialized equipment and techniques.

- CAPACITORS -

ference	Description					BEC Part No.
C101	Mylar	0.1 µF	±20%	200V	Sprague	230116
C102	Durmica	150 pF	±5%	500V	Arco DM-15-151J	200032
C103	Mylar	0.002 µF	±5%	200V	Sprague	234024
C104	Mylar	0.1 µF	±20%	200V	Sprague	230116
C105	Mylar	0.1 µF	±20%	200V	Sprague	230116
C106	Durmica	300 pF	±5%	500V	Arco DM-15-301J	200034
C107	Var. Air	3.5-15 pF			Jackson Bros. C804	275143
C108	Mylar	0.002 pF	±5%	200V	Sprague	234024
C109	Durmica	10 pF	±5%	500V	Arco DM-10C-100J	200022
C110	Durmica	120 pF	±5%	500V	Arco DM-15F-121J	200002
C111	Ceramic	36 pF	±5%	500V	Erie N750	220117
C112	Mylar	0.1 µF	±20%	200V	Sprague	230116
C113	Durmica	300 pF	±5%	500V	Arco DM-15-301J	200034
C114	Durmica	300 pF	±5%	500V	Arco DM-15-301J	200034
C115	Mylar	0.1 µF	±20%	200V	Sprague	230116
C116	Mylar	0.1 µF	±20%	200V	Sprague	230116
C117	Mylar	0.1 µF	±20%	200V	Sprague	230116
C118	Ceramic	36 pF	±5%	500V	Erie N750	220117
C119	Durmica	330 pF	±1%	500V	Arco DM-15-331F	200033
C120	Durmica	330 pF	±1%	500V	Arco DM-15-331F	200033
C121	Durmica	5 pF	±1 pF	500V	Arco DM-10C-050	200043
C122	Mylar	0.1 µF	±20%	200V	Sprague	230116
C123	Durmica	300 pF	±5%	500V	Arco DM-15-301J	200034
C124	Durmica	300 pF	±5%	500V	Arco DM-15-301J	200034
C125	Durmica	120 pF	±5%	500V	Arco DM-15-121J	200002
C126	Mylar	0.01 µF	±20%	200V	Sprague	234027

ference	Description				BEC Part No.
127	Mylar	0.01 µF ±20%	200V	Sprague	234027
128	Mylar	0.002 µF ±5%	200V	Sprague	234024
129	Durmica	120 pF ±5%	500V	Arco DM-15-121J	200002
130	Durmica	120 pF ±5%	500V	Arco DM-15-121J	200002
131	Mylar	6800 pF ±10%	200V	Sprague	234044
132	Mylar	0.1 µF ±20%	200V	Sprague	230116
133	Durmica	300 pF ±5%	500V	Arco DM-15-301J	200034
134	Durmica	300 pF ±5%	500V	Arco DM-15-301J	200034
135	Durmica	300 pF ±5%	500V	Arco DM-15-301J	200034
136	Durmica	300 pF ±5%	500V	Arco DM-15-301J	200034
137	Mylar	0.1 µF ±20%	200V	Sprague	230116
138	Mylar	0.002 µF ±5%	200V	Sprague	234024
139	Mylar	0.047 µF ±10%	400V	Sprague	234047
140	Mylar	0.002 µF ±5%	200V	Sprague	234024
201	Mylar	0.047 µF ±10%	400V	Sprague	234047
401a,b	Electrolytic	500-500 µF	450V	Mallory	283142
402a,b	Electrolytic	20-20 µF	450V	Mallory	283100

- RESISTORS -

ference	Description				BEC Part No.
101	Comp.	220K ±5%	1/2 Watt	AB Type EB	301143
102	Comp.	2.2K ±5%	1/2 Watt	AB Type EB	301095
103	Comp.	22K ±5%	1/2 Watt	AB Type EB	301119
104	Comp.	470Ω ±5%	1/2 Watt	AB Type EB	301079
105	Comp.	100Ω ±5%	1/2 Watt	AB Type EB	301063
106	Comp.	22K ±5%	1/2 Watt	AB Type EB	301119
107	Comp.	220K ±5%	1/2 Watt	AB Type EB	301143
108	Comp.	220K ±5%	1/2 Watt	AB Type EB	301143
109	Comp.	470Ω ±5%	1/2 Watt	AB Type EB	301079
110	Comp.	2.2K ±5%	1/2 Watt	AB Type EB	301095
111	Comp.	100Ω ±5%	1/2 Watt	AB Type EB	301063

5D

eference	Description					BEC Part No.
R112	Comp.	22K	±5%	1/2 Watt	AB Type EB	301119
R113	Comp.	2.2K	±5%	1/2 Watt	AB Type EB	301095
R114	Comp.	470Ω	±5%	1/2 Watt	AB Type EB	301079
R115	Comp.	10K	±5%	1/2 Watt	AB Type EB	301111
R116	Comp.	1M	±5%	1/2 Watt	AB Type EB	301159
R117	Comp.	1M	±5%	1/2 Watt	AB Type EB	301159
R118	Comp.	470K	±5%	1/2 Watt	AB Type EB	301151
R119	Comp.	47K	±5%	1/2 Watt	AB Type EB	301127
R120	Comp.	470Ω	±5%	1/2 Watt	AB Type EB	301079
R121	Comp.	10K	±5%	1/2 Watt	AB Type EB	301111
R122	Comp.	22K	±5%	1/2 Watt	AB Type EB	301119
R123	Comp.	47K	±5%	1/2 Watt	AB Type EB	301127
R124	Comp.	1K	±5%	1/2 Watt	AB Type EB	301087
R125	Comp.	470K	±5%	1/2 Watt	AB Type EB	301151
R126	Comp.	10Ω	±5%	1/2 Watt	AB Type EB	301039
R127	Var.	5K	±20%	3/8 Watt	CTS Type 330P	311222
R128	Comp.	680K	±5%	1/2 Watt	AB Type EB	301155
R129	Comp.	2.2M	±5%	1/2 Watt	AB Type EB	301167
R130	Comp.	2.2K	±5%	1/2 Watt	AB Type EB	301095
R131	Comp.	10K	±5%	1 Watt	AB Type GB	302125
R132	Comp.	510K	±5%	1/2 Watt	AB Type EB	301152
R133	Var.	2K	±10%	1/2 Watt	Bourns 200L-1-202M	311217
R134	Comp.	510K	±5%	1/2 Watt	AB Type EB	301152
R135	Comp.	510K	±5%	1/2 Watt	AB Type EB	301152
R136	Comp.	510K	±5%	1/2 Watt	AB Type EB	301152
R137	Comp.	7.5K	±5%	1/2 Watt	AB Type EB	301108
R138	Comp.	1M	±5%	1/2 Watt	AB Type EB	301159
R139	Var.	50K	±10%	2 Watt	AB Type J	311125
R140	Var.	100K	±10%	1/10 Watt	CRL-BA-001-385	311121
R141	Comp.	10K	±5%	1/2 Watt	AB Type EB	301111
R142	Comp.	1M	±5%	1/2 Watt	AB Type EB	301159

ference		Description				BEC Part No.
R201	Var. W.W.	50K	±5%	10 Turn Clarostat 62-JA-50K		311198
R202	Comp.	24K	±5%	2 Watt	AB Type HB	304120
R305	Var.	5K	±10%	2 Watt	AB Type J	311202
R401	Comp.	2K	±5%	1/2 Watt	AB Type EB	301094
R402	Comp.	1M	±20%	1 Watt	AB Type GB	302128
R403	W.W.	2K	±5%	5-1/4 Watt	Ohmite #2901	310110
R404	Comp.	120Ω	±5%	1/2 Watt	AB Type EB	301065
R405	Comp.	2.2Ω	±5%	1/2 Watt	AB Type EB	301501

- DIODES -

ference	Description			BEC Part No.
CR101	Silicon	1N251	Texas Instrument	530043
CR102	Silicon	1N914	Texas Instrument	530058
CR103	Silicon	1N914	Texas Instrument	530058
CR104	Germanium	1N58A	Sylvania	530021
CR105	Germanium	1N58A	Sylvania	530021
CR106	Silicon	1N914	Texas Instrument	530058
CR107	Germanium	1N58A	Sylvania	530021
CR108	Silicon	1N251	Texas Instrument	530043
CR401	Silcon Bridge	SPF-GR	Solitron	532006
CR402	6.2V Zener	1N753	Motorola	530062
CR403	6.8V Zener	UZ806	Unitrode	530041

- TRANSISTORS -

ference	Description			BEC Part No.
Q401	PNP	2N404	Texas Instrument	528009
Q402	PNP	2N554	Motorola	528003

- TUBES -

Reference	Description	BEC Part No.
V101	6AU6	526 6AU6
V102	6AU6	526 6AU6
V103	6AU6	526 6AU6
V104	6AU6	526 6AU6
V105	6AU6	526 6AU6
V106	12AT7	526 12AT7
V107	12AT7	526 12AT7
V401	6X4	526 6X4
V402	0A2	526 0A2

- INDUCTORS -

Reference			Description		BEC Part No.
L101	Var.	RF	100-175 µH	North Hills 1500A	400115
L102		RF	1000 µH	Stanwyck Dink-1000	400135
L103		RF	1000 µH	Essex	400095
L104	Var.	RF	100-175 µH	North Hills 1500A	400115
L105		RF	1500 µH	Stanwyck Dink-1500	400136
L106	Var.	RF	100-175 µH	North Hills 1500A	400115
L107	Var.	RF	100-175 µH	North Hills 1500A	400115
L108		RF	1000 µH	Essex	400095
L401	Power		7H 500Ω 50 mA	Stancor C1707	440001

- TRANSFORMERS -

Reference	Description		BEC Part No.
T401	12.6V Filament	Stancor P8130	446010
T402	Power	Stancor 1377	446007

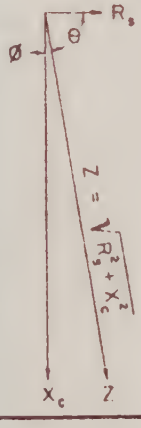
- SWITCHES -

Reference	Description	BEC Part No.
S101a,b	Slide DPDT Continental Wirt Type G-326	465125
S201a,b	Rotary 2P - 4 Pos Oak Type J	466171
S401	Toggle SPST Carling #110-63	465105

- MISCELLANEOUS -

M101	Meter	50-0-50 µA	Ammon Type AM-3	554181
Y101	Crystal	1 MHz	James Knight CR 18/U	547015
F401	Fuse (Slo Blo)	0.5A @ 250V	Buss MDL 1/2	545504
PL401	Lamp	14V 80 mA	GE Type 330	545110

CAPACITANCE/LOSS FORMULAS

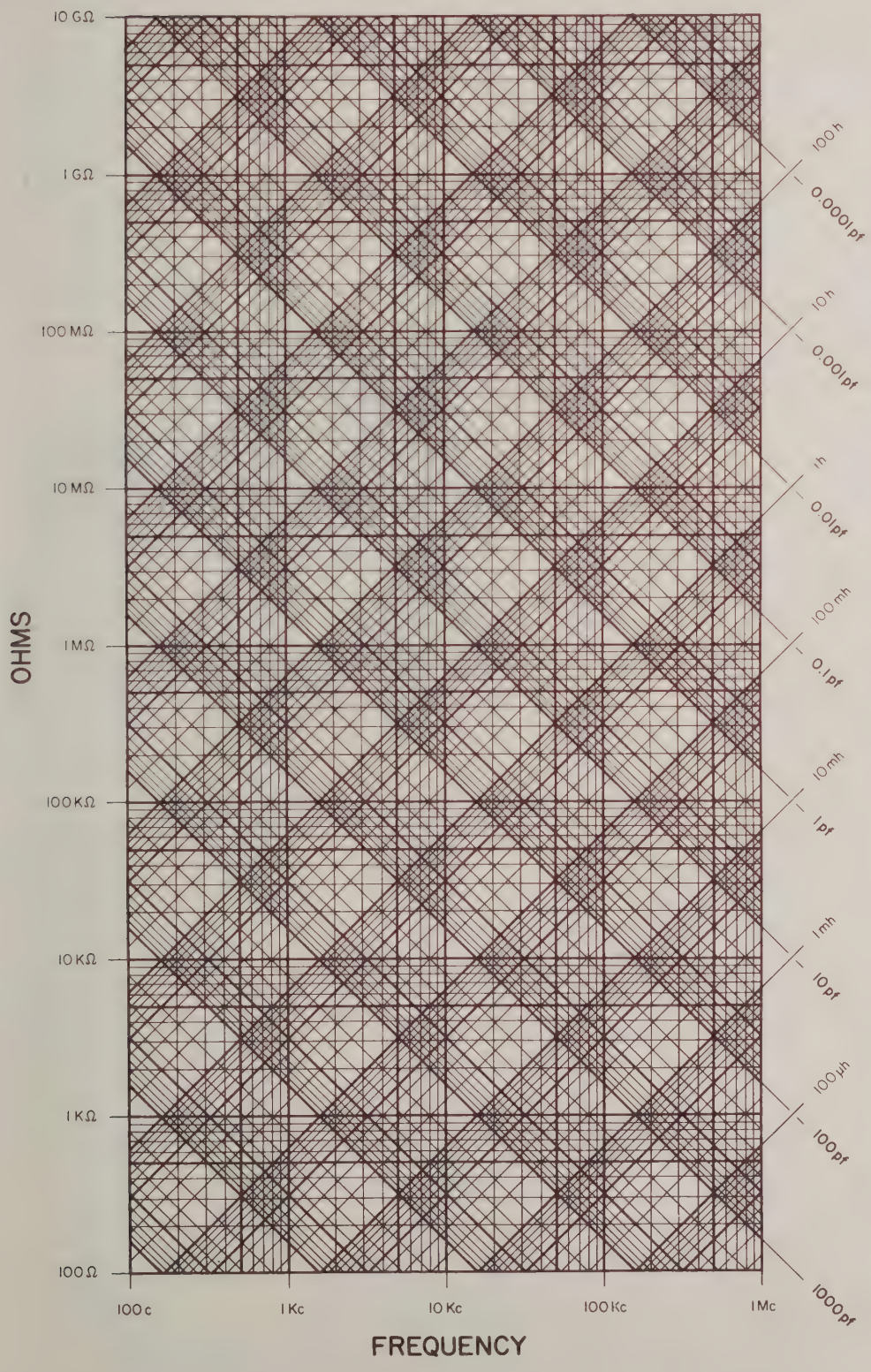
IN TERMS OF → / TO OBTAIN ↓	D	Q	G	R_s	R_p	Ø	θ
D =		$\frac{1}{Q}$	$\frac{G}{\omega C}$ / $X_c G$	$\omega C R_s$ / $\frac{R_s}{X_c}$	$\frac{1}{\omega C R_p}$ / $\frac{X_c}{R_p}$	TAN Ø	COTAN θ
Q =	$\frac{1}{D}$		$\frac{\omega C}{G}$ / $\frac{1}{X_c G}$	$\frac{1}{\omega C R_s}$ / $\frac{X_c}{R_s}$	$\omega C R_p$ / $\frac{R_p}{X_c}$	COTAN Ø	TAN θ
G =	$\omega C D$ / $\frac{D}{X_c}$	$\frac{\omega C}{Q}$ / $\frac{1}{Q X_c}$		$(\omega C)^2 R_s$ / $\frac{R_s}{X_c^2}$	$\frac{1}{R_p}$		
R_s =	$\frac{D}{\omega C}$ / $D X_c$	$\frac{1}{\omega C Q}$ / $\frac{X_c}{Q}$	$\frac{G}{(\omega C)^2}$ / $G X_c^2$		$\frac{1}{(\omega C)^2 R_p}$ / $\frac{X_c^2}{R_p}$		
R_p =	$\frac{1}{\omega C D}$ / $\frac{X_c}{D}$	$\frac{Q}{\omega C}$ / $Q X_c$	$\frac{1}{G}$	$\frac{1}{(\omega C)^2 R_s}$ / $\frac{X_c^2}{R_s}$			

The angle Ø in radians, by which the current fails to lead the voltage by 90°, is very nearly equal to the power factor for P.F.'s of 10% or less. It is also approximately equal to the dissipation factor, D, but at large angles of Ø, D departs more rapidly than P.F.

$$P.F. = \frac{R_s}{Z} = \frac{1}{\sqrt{1+Q^2}} = \cos\theta$$

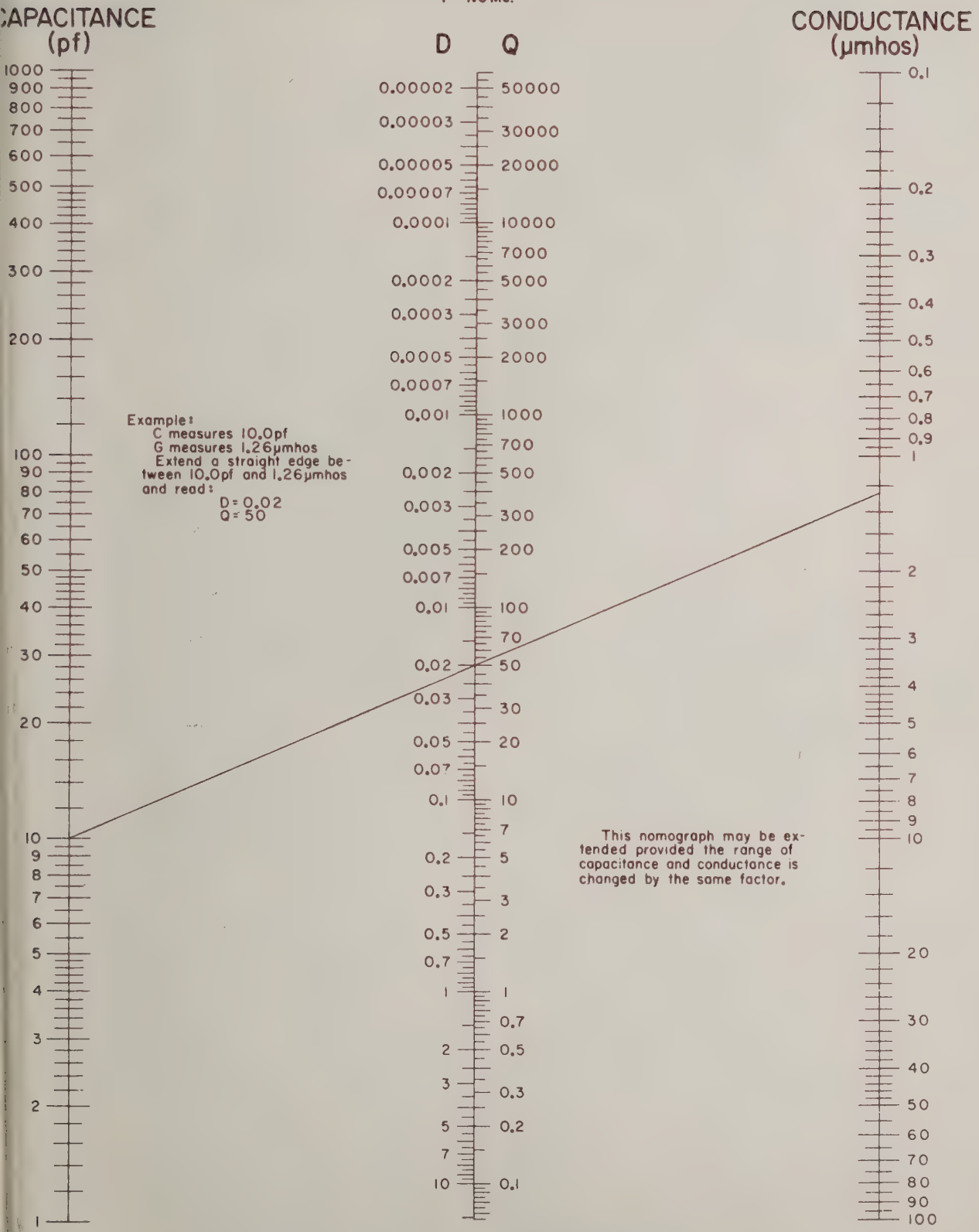
$$\text{if } Q \geq 10, \quad P.F \approx \frac{1}{Q} = D$$

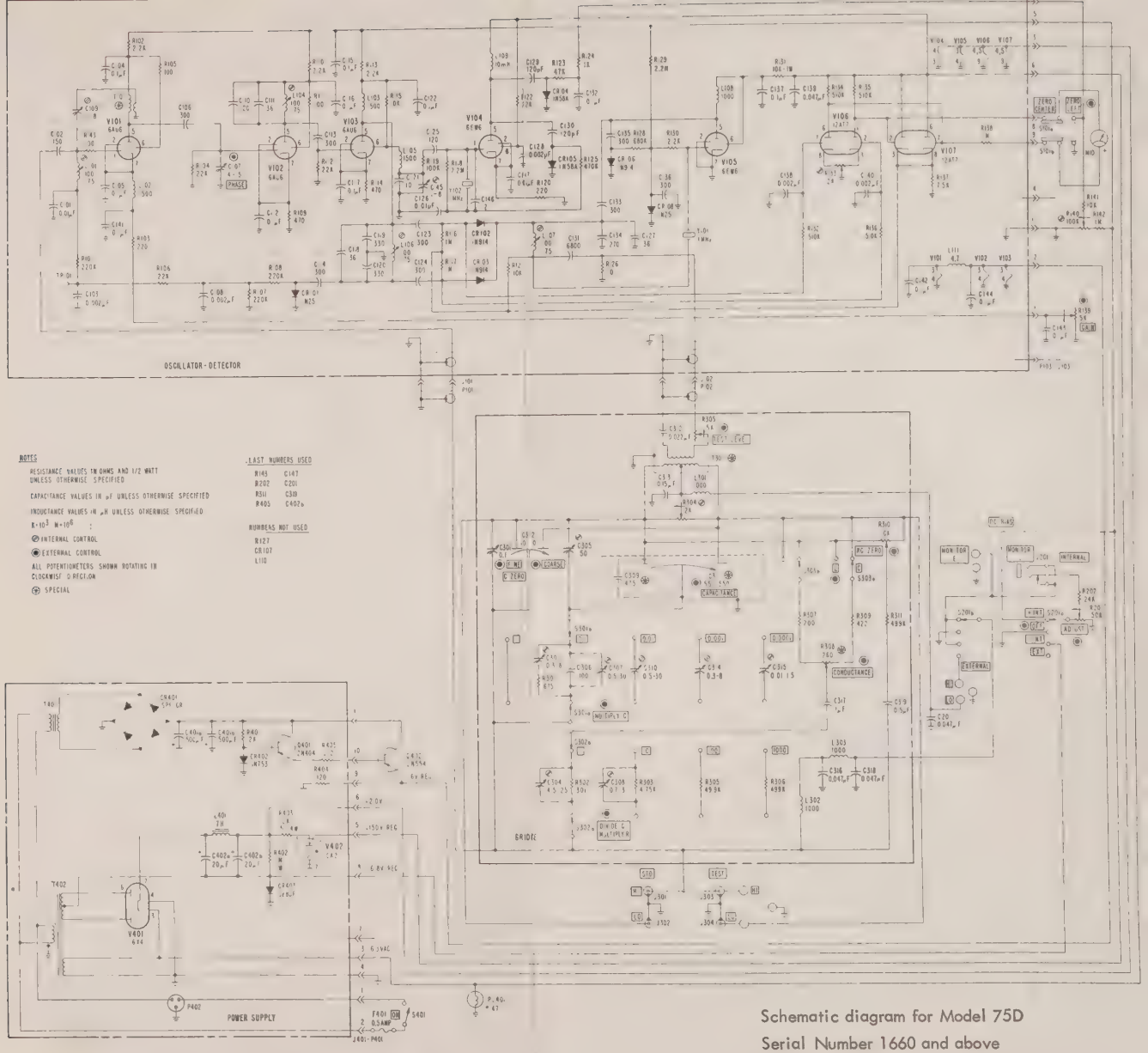
CAPACITANCE BRIDGE REACTANCE CHART



Nomograph for D or Q of Capacitors

f = 1.0 Mc.





Schematic diagram for Model 75D
Serial Number 1660 and above
(Dwg. No. 830395 E)

Warranty

Boonton Electronics Corporation warrants its products to the original Purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty.

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